CONTENTS.

THE HAWAIIAN PLANTERS' MONTHLY

PUBLISHED FOR THE

HAWAIIAN SUGAR PLANTERS' ASSOCIATION.

[Entered at the Post Office at Honolulu, T. H., as Second-class matter.]

Vol. XXV.] HONOLULU, APRIL 15, 1906. [No. 4

WEATHER AND CROP.

The early part of the month was marked by cold and unusually dry weather, unfavorable for the growth of sugar cane, but permitting continuous harvesting and grinding. During the middle of the month there were fairly heavy rains in Hawaii, Maui and Oahu, but on the whole the average rainfall for the month has been much below normal.

On plantations where labor conditions are satisfactory all plantation operations—harvesting, grinding and planting—are in full swing; many plantations, however, are handicapped by a shortage of labor and are unable to run their mills full time, and also carry on field operations.

Sugar is beginning to accumulate at the various ports of shipment and all sugar vessels are promptly loaded.

SUGAR PRICES MONTH ENDING APRIL 19, 1906.

	Centrifugals.	Beets.
March 15	3.51c	8s 5¼d
March 22	3.5625c	8s 5¼d
March 29	3.50c	8s 4½d
April 5	3.55c	8s 6d
April 12	3.48c	8s 6d
April 19	3.42c	8s 6d

Under date of April 12, Czarnikow, Macdougall & Co. reports as follows:

The lack of demand that prevailed last week has continued, especially for sugars on the spot or for shipment this month. Refiners, having such heavy direct receipts as to compel them to resort to storing, naturally do not wish any more nearby sugars, and the result has been that offerings of Cubas for early shipment could only find buyers at 2⅛c., a decline of 1-16c. Although this concession had to be made on spot and prompt sugars, it has been possible to sell May at the price current last week, namely 2 3-16c. c. f., 96°.

April shipments from Cuba will be large, but fortunately for the market, the bulk of them have been sold ahead. So far no considerable business has been done for May shipment, but before the advent of that month, the probabilities are that large quantities will have been marketed; consequently, the receipts throughout this and next month, especially from Cuba, are likely to keep up with the meltings.

The principal factors affecting the markets, both here and elsewhere, are the prospective outcome of the Cuban crop and the probable extent of the European beet sowings. As to the latter our cables report that Gieseker has just issued a statement to the effect that there will be no reduction in sowings in Austria and in Germany, while mail advices state that the average reduction in France will probably be 20 per cent.; in Bohemia, 15 per cent.; in Moravia, 6 per cent.; and that in Hungary there will be no reduction. There have been labor troubles in some Continental refineries, but they do not seem likely to have any influence on the situation.

With regard to the Cuban crop, the production during March was 36,500 tons in excess of the quantity made in the same month last year. This reduces the crop shortage, up to March 31st, to 169,000 tons.

ON THE SUPERINTENDENCE OF SUGAR MILLS.

Editor Planters' Monthly:

In your December number you published a letter signed "Sugar-boiler." The statemnts in this letter can, of course, not be taken seriously. At the same time, considering, that the views of "Sugar-boiler" are probably shared by many of his colleagues, it may be advisable to point out for the benefit of the sugar manufacturer, that it cannot be to his best interest to leave the superintendence of the more or less complex scientific processes to anyone lacking scientific training.

Sugar-house economy has been brought to a higher degree of perfection in Java than in any other cane sugar producing country. This is undoubtedly to a large extent attributable to the absence of the "Sugar-boiler" of the type we find in the majority of American sugar mills. The latter has, owing to the considerable amount of authority vested in him, been able to greatly retard progress. The sugar-boiling in Java is done exclusively by Chinese and natives working under the direction of the superintendant, who is in almost every case a chemist; in a few exceptional cases the engineer (also a scientifically trained man) holds this position. The "Sugar-boiler," as you know him, is unknown there.

While in other sugar countries, producing either beet or cane sugar, the modernization of machinery went hand in hand with the modernization of the management, you seem still to be passing through a transition period, which will of necessity last until there will be enough men, whose scientific training combined with practical experience fits them to fill the position of sugar mill superintendent.

CORRESPONDENT.

ACTION OF SWEET WATER ON BOILERS.

Central Aguirre, Porto Rico,

March 10, 1906.

According to what we have experienced here during the crop of 1905. the use of sweet water has a destructive effect on Sterling boilers, while the use of the same water at the same time in boilers of other types, such for instance, as locomotive boilers, did not harm them at all. Now in order to find an explanation for this seemingly strange fact, we have to consider all that was observed here regarding boilers and water.

(1) Water samples taken from the affected boilers according to repeated tests made in the laboratory with ferri and ferro cyanide of potassium contained iron in solution. As this test is not a very sensitive one, the presence of iron cannot be attributed to the dissolving action of pure water.

(2) The original slight alkaline reaction of sweet water was lost in the boilers and after a long boiling even turned into an acid one.

(3) Addition of a fixed alkali (lime, soda) acted protectingly on the boilers.

(4) The boilers which have been mostly affected have no circulation tubes for water between second and third dome, and only the upper parts of the tubes ending in the dome (third), which is the last in the way of the water, have been eaten away, while large deposits of iron oxide have been found in the first dome. Now, as the latter as well as tubes ending in it did not

show any signs of corrosion, the iron oxide found there must have been formed by precipitation of iron in solution. This precipitating action is due to ammonia which is always present in sweet water in a free state, and most probably also in combination with volatile organic acids, especially in water obtained from not overlimed juices. A test made in the laboratory with iron shavings showed that sweet water when kept alkaline (while boiling) with ammonia does not attack iron, while water to which an organic ammonia salt (acitate of ammonia) was added destroyed the said shavings in a very short time. As already mentioned, the presence of traces of organic ammonia salts in sweet water is more than probable, and as these salts are easily decomposed by heat, giving off ammonia, the acid principle contained in them may, even when present only in traces, have a destructive effect on boilers of the Sterling type. In these boilers the incoming water is always moving in one direction and reaches the last dome only after passing a long way through heated tubes and consequently after losing ammonia. In case of ammonia salts being present, the dissolving of iron by the acid principle contained in the salt is therefore only to be expected, and as the thus formed iron salt must according to the law of diffusion spread through the whole mass of the water and enter, therefore, the other parts of the boiler, iron oxide will be precipitated there where free ammonia is coming in with the water. In this way is the original ammonia salt regenerated and carried again in the direction of the last dome. As the described process can be indefinitely repeated, a small quantity of a solvent of this kind must be sufficient to put a boiler out of action in a short time. Now what would happen in such a case with a multitubular boiler, for instance? Of course, when the water inlet is shut off for the first time iron will get dissolved and when new water is let in iron oxide will be precipitated by ammonia, but as dissolving and precipitation are not separated by space as in case of Sterling boilers, the formed iron oxide will now absorb any acid set free again and the process of dissolving metallic iron could not be repeated. But whether the action of sweet water is really due to salts being present or not, one thing is at any rate sure, viz., that this action does not take place when the water contains free ammonia. Sweet water may therefore be safely used in boilers of the multitubular type, because in those boilers the incoming water which contains free ammonia is mixed with the whole mass of the boiling water. It can also be used in Sterling boilers only in that case, and addition of a fixed alkali is indispensable.

(Signed) M. L. KAPLAN, PH.D.

WHAT IS THE JAVA PROCESS?

The term "Java Process" seems to be used rather indiscriminately in regard to the method of boiling in many factories, which gives an erroneous impression of what is really accomplished by the various methods employed in these factories.

The manager's report of mill work at Olaa, shows that the Java process of boiling was employed in that factory last season, while the chemist's report of mill work for the same season shows that a method of boiling quite foreign to that introduced in Hawaii from Java, was employed.

What has become known as the "Java Process" was introduced here the latter part of the season 1904 by Mr. K. R. Hamakers, and provides for the making of *two* grades of sugar only. The first massecuite is made of syrup and first molasses, and must have a purity of 70 and brix of 95 when finished. This is cooled in a crystallizer to 40° C., the sugar separated in centrifugal machines, during which process sufficient water is added to bring its polarization to 96.5-97, after passing it through a Hersey granulator.

The second massecuite is made of syrup and first molasses and must have a purity of 60 and brix of 95.5 when finished. This is cooled in a crystalizer to 32° C., the sugar separated in centrifugal machines, and washed as the first grade sufficiently to bring its polarization to 96.5-97, after passing it through the granulator.

The wash from this grade must be separated by some mechanical arrangement underneath the machines, and reboiled in succeeding strikes of the same grade.

The molasses from this grade will have a purity not higher than 32.5, but the success of this method depends entirely on the boiling, providing the molasses can be renewed occasionally as it becomes viscous.

The sugars may be mixed or not, since they are of one quality, and the redeeming feature claimed for this method is that a waste molasses and one quality of sugar are produced, not several qualities mixed together.

It is the aim in all factories to reduce operating expenses, and losses in manufacture to a minimum.

The next step forward, is to demonstrate by which of the various methods producing equally good results, the most sugar can be produced per day, since on this depends the cost of manufacture.

Mr. Hamakers offered many suggestions intended for improvements in methods of boiling in various factories not provided with the necessary machinery for working the Java Process, but the value of these has remained for the operatives to demonstrate.

Since the Java Process was unknown in Hawaii before his arrival, it would convey a clearer idea to manufacturers, if in referring to this process they consider only that introduced from Java, and not any method by which low grade sugar may be worked into commercial sugar, as that was not only known, but accomplished several years before Mr. Hamakers' arrival.

OBSERVER.

BEET SUGAR BY-PRODUCTS.

LESSONS TO BE LEARNED FROM SCIENTIFIC GERMAN METHODS.

Consul-General Thackara supplies a valuable report from Berlin on German scientific methods of securing the highest unit value for every part of the sugar beet. Americans have been equally successful in the close utilization of the cotton seed, and are fully capable of developing the fullest economies in handling the sugar beet. Mr. Thackara's letter reads:

There is probably no industry in Germany to which more attention has been given and more scientific knowledge applied than that of the manufacture of sugar from beets. It is estimated at the present time that there are over 1,000 chemists in Germany working in up-to-date laboratories in the interests of the sugar industry.

MOLASSES THE MOST VALUABLE BY-PRODUCT.

One of the principal by-products resulting from the different processes for the extraction of sugar from the beet is molasses. During the campaign of 1904-5, when 1,605,438 tons of raw beet sugar were produced, the output of this by-product was 366,860 tons. Taking the present price at the factory of 71.4 cents per 110.2 pounds, or $14.30 per ton, the value of the molasses by-product was about $5,250,000. In Germany, where the prices of all kinds of fodder are comparatively high, the farmers employ the refuse molasses as one of the component parts of their cattle feed.

It is either fed directly to the animals in a thinned condition or mixed with ground palm seed, rape seed, cocoa or peanut shells, dried brewers' grains, fresh blood, and with other by-products or wastes from different agricultural industries. It is sometimes used with peat, which has been found by experience to be not only a good vehicle for carrying the molasses, but the chemical properties of the peat act as a preventive of the evil effects of the molasses, which is apt to produce diarrhœa in animals if not fed with caution. The proportion of molasses should be from 35 to 40 per cent., the exact amount to be absorbed being determined by experiment. A mixture containing not more than 40 per cent. of the sirup, if not exposed to dampness, may be stored for several months without deterioration. If, however, there is more than 40 per cent. of molasses in the mixture, even if the moisture is driven off by heat, the resulting compound will be affected by the humidity of the air. A durable food mixture may be obtained by using beet pulp with the molasses. Fresh dried beet pulp which has been well pressed out and its sugar contents exhausted is mixed with molasses in the proportion of one part of the sirup to two or three parts of the dried pulp. By the aid of a kiln-drying process any moisture remaining in the mixture is driven off, and the resulting product may be stored for years with but little danger of being affected by atmospheric conditions.

Owing to its high price, due principally to its increasing demand as a food for animals, molasses is comparatively little used in Germany at the present time by the distilleries, as alcohol made from the sugar by-product can not compete in price with potato alcohol. Distilleries not connected with farms no longer receive bounties. The German molasses distilleries produced, during 1903-4, 2,450,000 gallons of alcohol, a small quantity when compared with the average annual production of potato alcohol of about 80,500,000 gallons.

MOLASSES HAS MANY USES.

Molasses is employed in comparatively small quantities in the manufacture of brewers' yeast, dyes and dyewood extracts, shoe polish, chicory, table sirups, ordinary candies, etc. The increasing use of aniline colors for dyeing purposes has greatly reduced the consumption of molasses in the manufacture of the vegetable dyes. Formerly larger quantities of the crude sirup were employed in making shoe blacking, but the great and continually increasing competition met with in the use of shoe dressing and creams has considerably lessened the amount of molasses consumed for this purpose.

Molasses is also employed in Germany to some extent in the manufacture of chicory. The finished produce, sold under the trade name of "kaffee surrogat," has a market value at the factory of $8.81 per 220.46 pounds wholesale, or about 4 cents per pound. The processes, mixtures, etc., in which molasses is used in the industrial arts are the result of costly experiments extending over many years.

Probably the most important waste products of the beet-sugar manufacturers are the spent pulp from the presses and the beet cuttings. They are highly prized by the German farmer as an excellent fodder for his cattle, which can be preserved for use throughout the winter. When waste molasses is added to the dried pulp the food is rendered more palatable for the animals, and, being fed on the farm, the potash of the sirup is retained on the premises and restored to the land in the form of stable leachings and manure. These products in Germany are known under the name of "schnitzel."

From 40 to 50 per cent. of the wet schnitzel is usually returned gratis to the farmers who furnished the beets, the remainder either being sold at the factory for from 2¼ to 9½ cents per 110 pounds, or is used by the factory owners for their own farm purposes. The neighboring farmers store it in their silos. The schnitzel is also dried at the factories in special drying apparatus.

SUGAR SCHNITZEL AND BEET TOPS.

The schnitzel resulting from the Steffen Bruh process of extracting sugar, called sugar schnitzel, is attracting considerable attention among the German farmers. Its large sugar percentage makes it an exceptionally good fodder for horses and for fattening cattle and pigs. The beet leaves and tops are also utilized by the German farmers as food for cattle. When fresh, however, owing to the oxalic acid contained in them, they are apt to have great purgative effect on the animals. In some cases, to overcome this difficulty, carbonate of lime, in the form of the precipitates from the sugar factories, is sprinkled over them when they are being stored in the silos.

The spent pulp (scheideschlamm) and the mud remaining after washing the sugar beets are good fertilizers, especially for use in light soils. They are either given gratis to the farmers who supply the beets or sold at the factories. The prices of the spent pulp range from 19 to 24 cents per 220.46 pounds and the earth from one-half to seven-tenths of a cent. A part of the refuse liquor from the extraction of sugar from molasses is worked up into raw potash (schlemperkohle), which is either sold to chemical factories, such as that at Dessau, to be manufactured into commercial potash, or to farmers as a fertilizer, and a part is delivered in its liquid form for use on the neighboring farms. The lime precipitates (scheidekalk) are also sold as fertilizers for prices varying from 2.4 to 8 1-3 cents per 110 pounds. It has been found that when beets are diseased, owing to the presence of injurious bacteria, the mud containing these bacteria is apt to infect the fields upon which it is used as a fertilizer. An efficient method of sterilizing the mud not having as yet been found, although many experiments in this line have been made. Care should be taken in the use of this fertilizing material.

AMERICA SHOULD USE BEET WASTE.

In the United States where the manufacture of sugar from beets may be said to be in its infancy, but which in the past few years has made gigantic strides—from six factories some eight years ago which extracted only 30,000 tons of beet sugar to 54 factories which it is estimated produce 295,000 tons, valued at $15,000,000—the question arises whether or not our beet sugar makers thoroughly appreciate the economic value of the by-products. Are the latter not considered a drawback, to be removed either at too low prices or to be given away gratis provided the receiver pays the cost of hauling?

If American farmers and sugar makers desire to save the enormous sum over $90,000,000 which we now have to pay to foreign nations for the sugar necessary to supply the wants of our own consumers, and at the same time to build up an industry which will not only benefit our farmers but also their land, they can not afford to ignore the scientific economies of sugar production.

FORESTRY IN HAWAII.

By Ralph S. Hosmer.

The essential features of the forestry work now being conducted in the Territory of Hawaii are the creation of forest reserves and the planting of waste and barren land with trees of economic value.

Forest reserves are established with the main object of protecting the watersheds of streams important for irrigation. For this purpose the Hawaiian forest is admirably adapted, for with its dense mass of luxuriant undergrowth it makes a cover which absorbs a large portion of the heavy precipitation, retards the run-off on the steep slopes, and equalizes the flow in the streams which lower down supply the irrigation ditches.

The forest work of the Territory is performed by the division of forestry of the Board of Commissioners of Agriculture and Forestry, an unpaid board appointed by the Governor and constituting, with its several divisions, the Territorial department of agriculture. Under the terms of the law creating the Board the Superintendent of Forestry must be a professional forester of experience. To him is intrusted the administration and execution of all matters pertaining to forestry within the Territory.

During the past year the energies of the division of forestry have been largely directed toward the creation of forest reserves on the several islands. Much work of a preliminary nature has been done in the way of examining lands and preparing reports, which in the coming months will lead to action of far-reaching importance. Two tracts of forest land on the Islands of Oahu and Hawaii have been set apart as forest reserves by proclamation by Governor Carter. These reserves comprise, respectively, 913 and 18,940 acres. Pending on June 30, and proclaimed a reserve by Acting Governor Atkinson on July 24, 1905, was a tract of 110,000 acres in the district of Hilo, Island of Hawaii. Other large projects on Maui and Kauai, embracing, respectively, 43,-000 and 37,500 acres of forest land, are so well under way that final action will be taken on them during July or August.

In creating forest reserves it is the custom of the Board of Agriculture and Forestry to recommend a definite area, which it believes it is to the best interest of the Territory to maintain under forest cover. The Governor in declaring this area a reserve sets apart as compartments thereof the government lands within its boundaries not then under lease or on which the existing leases have less than two years to run. The individuals or corporations owning or leasing land within the reserve are then requested to co-operate with the government, under the law, in carrying out the objects for which the reserve is set apart. This they are usually willing to do, because the establishment of the reserve is almost directly to their advantage in that they reap the most direct and immediate benefits from the stream protection afforded by the forest cover.

Not only are the large interests willing to coöperate with the government in forest work, but many have gone so far as to establish and maintain private forest reserves covering extensive areas and protected from cattle at great expense. Prominent in this work is the Bishop estate, which has for some time maintained private forest reserves aggregating 18,500 acres on the Island of Hawaii and 20,700 acres on Oahu. Plans for setting apart large additional areas on these two islands and on Kauai are already well developed, and in each case where the Bishop estate had lands within the areas proposed by the government as forest reserves, the response of the trustees to suggestions of co-operation has been prompt and cordial.

Other notable instances of corporation interest in forestry are afforded by Messrs. C. Brewer & Co., who have for a number of years maintained a private forest reserve of approximately 25,000 acres in the district of Kau on Hawaii; by the Baldwin interests on Maui, and by the Lihue Plantation Company on Kauai. This phase of forest work will be continued during the coming year, and will be vigorously pushed until the protection of the forest on the important watersheds on each of the larger islands is secured.

The work of the division of forestry toward the introduction of exotic trees and the planting of waste areas has, during the past year, been mainly in the way of furnishing good tree seed to prospective planters and by advising them as to the ways and means to be followed to insure success in making forest plantations. Seed of the important trees, both native and introduced, has been collected, and is held on sale at prices just covering the cost, while those wishing only a few trees can obtain them as seedlings from the government nursery. The nursery also provides, free of charge, ornamental and forest trees for use on school grounds and around public institutions.

Limited appropriations have prevented any extensive forest planting by the government, but in coöperation with ranch and plantation companies throughout the Territory a considerable quantity of seed has been furnished for experimental purposes. As this seed is tried under varying conditions of soil, aspect, and elevation, the results obtained will, when compiled, be of much value in future work.

A number of the large corporations have taken an active interest in forest planting in past years and, with certain of them, it has become a fixed policy to put in annually a certain number of thousand trees or to plant a definite area. The forest plantations near Lihue, Kauai, and on the Island of Maui stand out with special prominence because of the size of the areas planted and the sustained interest manifested throughout a long term of years. But throughout the Territory much commendable work has been done by other corporations and by individuals. It is the desire and intention of the division of forestry to help and encourage this work in every possible way.

During the long drought from which the Territory suffered during the early months of 1905 there were a number of forest fires on the different islands. While the areas burned over were not large in terms of the mainland, the damage done was considerable. As Hawaiian forests are easily destroyed, forest fire is a serious menace here as it is elsewhere. Prompt action by the legislature, which was then in session, in appropriating a special fund for fighting fire enabled the Board to put a force of men in the field and to get the largest of the fires, which was on government land, under control. The others were extinguished by the corporations on whose lands they occurred. Later in the session a forest-fire law was enacted, which, it is believed, will help in controlling if not in preventing future fires.

One other matter of forest interest should be mentioned here. That is the decision of the Bishop estate to lumber a section of the koa forest on its land in the district of Kau, on Hawaii. Koa is the most valuable of the Hawaiian woods and for beauty of color, grain, and texture should easily take its place in the first class of woods used for high-grade interior finish and cabinet work. As a step toward the economic development of the Hawaiian forests this undertaking is significant.

As a whole the outlook for forestry in Hawaii is promising. The necessity of watershed protection makes the needs of a forest cover apparent, and an excellent public sentiment supports the work which is undertaken. This, with the increasing interest in forest planting, should assure continued financial support. The field for forest work in Hawaii is a large one, and the results obtained help to strengthen the foundations on which the continued prosperity of the Territory rests.

ENTOMOLOGY.

By Alexander Craw.

Hawaii early recognized the importance of naturally controlling the destructive insects that had been introduced upon trees and plants brought from other countries by her citizens, in an effort to secure the best plants and fruits to be had in the world. In the primary efforts to subdue the injurious insects recourse was taken to the old methods of controlling such pests—by the use of spray mixtures, poisons, and poisonous gases for fumigation—but without any practical results. The successful work with beneficial insects in subduing insect pests in California was taken up by the agricultural authorities of Hawaii and the services of Prof. Albert Koebele were secured for collecting beneficial insects in foreign countries and introducing and establishing them in Hawaii. His work in this line has been so successful that now some of the former serious introduced pests have been brought under subjection without any immediate personal outlay to the agriculturist or fruit grower.

A few years ago a sugar-cane pest (*Perkinsiella saccharicida*, Kirk.) made its appearance in the sugar-cane fields of Hawaii, introduced, it was supposed, from Australia. It has been stated that this pest caused a monetary loss of upward of $3,000,000 to the sugar interests of Hawaii the past year. It was so destructive to the industry that the Hawaiian Sugar Planters' Association a year ago joined the Territorial Board of Agriculture and Forestry and engaged Prof. R. C. L. Perkins, then acting superintendent of entomology for Hawaii, to accompany Professor Koebele on a mission to Australia to search for the natural enemies of the "cane-leaf hopper." It did not take their trained eyes long to discover the insects that were holding that insect in check.

A few of each were successfully introduced and established here, and now they have been propagated and planted on the various islands and are well established wherever placed. One of the most important is a very minute fly that destroys the eggs of the "leaf hopper" by inserting its ovipositor into the leaf-hopper egg and depositing therein an egg, which soon hatches into a small, blind, footless grub, afterwards changing to a pupa and fly; and in the latter stage it cuts its way out and is soon ready to continue the good work.

For the better protection of the Territory the Board of Agriculture and Forestry has issued regulations against the importation of certain fruits from countries or districts infested with fruit flies. To further protect the islands from injurious insects and plant diseases, I addressed a letter, on November 28, 1904, to the Hon. James Wilson, Secretary of Agriculture, who, in conjunction with the Secretary of the Treasury, obtained for us permission to immediately fumigate with hydrocyanic-acid gas all cases of plants or trees arriving for this Territory. This privilege is most important, as it will destroy any insects that have developed on the voyage or on the dock before inspection and delivery of the plants.

One of the most important divisions of the work of the board is the propagation or collection and distribution of beneficial insects and fungous disease for the suppression of insect pests. Not only that, but economic entomology has been drawn upon for checking the too great increase of noxious weeds and undesirable plants. Probably Hawaii is the first country that purposely introduced insects for the suppression of the latter, as instance the work but recently accomplished in checking the lantana that was introduced as a choice flowering shrub, and by the assistance of the wild doves and "Mynah" birds the seed was scattered until it took possession of all uncultivated lands, destroying the value of it for pasture, as the hills and valleys were covered with an almost impenetrable jungle of thorny bushes. Professor Koebele collected in Mexico the various insects that work exclusively upon the plant and forwarded them to Professor Perkins, who propagated and distributed them on the islands, and the value of their work is now evident in the dried-up, defoliate branches of lantana.

The more important insects are a small, bluish butterfly, the larvæ of which destroys the flowers, and a small, dark fly, the maggots of which destroy the lantana seeds, thus checking the increase and spread of the pest, so that hereafter when land is cleared it remains so. In the destruction of the foliage a leaf miner and a tingidæ play important parts.

Agriculture and horticulture will probably continue to be the principal industries of this Territory, and the Territorial and Federal governments, as well as the Hawaiian Sugar Planters' Association, have well-equipped entomological establishments for carrying on the particular work that each has to attend to.

The Federal experiment station has a division of entomology, of which Mr. D. L. Van Dine has charge, and it gives special attention to agricultural pests. The Hawaiian Sugar Planters' Association has a large and well-organized staff of entomologists devoting their entire time to insects pertaining to sugar cane and the propagation of parasites and predaceous insects that infest cane. Prof. R. C. L. Perkins is in charge, and has a thorough knowledge of the fauna of the islands.

The Territorial Board of Agriculture and Forestry entomologists are located at the board's headquarters and grounds on King street. The duties of that division are to guard against the further introduction of insect pests and diseases into the Territory. Inspectors board all vessels arriving from outside points and all plants are examined and, if deemed necessary, are fumigated with hydrocyanic-acid gas. The board is well equipped with fumigating chambers on the principal docks, where the work of disinfection can be thoroughly and promptly done. By the sanction of the postal authorities all plants received by mail are also inspected, as it is a well-known fact that such small plants frequently harbor injurious pests and diseases. All this work should reduce to a minimum the danger of introducing new pests and blights on the islands. The Territorial entomologists also attend to the propagation and distribution of parasitical and beneficial insects for the suppression of noxious insects infesting trees and plants, as well as insects for the control of lantana.

Under the instigation of Mr. Jacob Kotinsky, assistant Territorial entomologist, an entomological society was organized on January 26, 1905, of which Prof. R. C. L. Perkins is president and Jacob Kotinsky is secretary-treasurer. The society meets monthly and now has a membership of 20.

LEAF HOPPERS AND THEIR NATURAL ENEMIES.

GENERAL ACCOUNT OF WORK DONE IN AUSTRALIA, FIJI AND THE UNITED STATES.

The material on which this Bulletin, entitled "Leaf-Hoppers and Their Natural Enemies," is based, has been derived from various localities and sources, which are herewith specified.

(1). In 1903 Mr. Koebele made extensive observations on this subject in North America, chiefly in the States of Ohio and California, and sent a large amount of living material to the Hawaiian Islands.

(2). In 1904 Mr. Koebele, accompanied by the writer, visited

Australia and a still larger collection of leaf-hoppers and their enemies was made in that country.

(3). In the early months of 1905, after I returned to these islands, Mr. Koebele spent a short time in Fiji, continuing Australian studies.

(4). For several years the sugar-cane and some other leaf-hoppers and their enemies have been under close observation in the Hawaiian Islands, and a collection of these has been made.

I will now make some remarks on these various expeditions, showing what was achieved in each case.

KOEBELE'S MISSION TO THE UNITED STATES.

Mr. Koebele's researches in Ohio in 1903 were primarily undertaken on information kindly given him by Dr. L. O. Howard, of the Department of Agriculture. A short time previously Mr. Otto H. Swezey had discovered that certain leaf-hoppers in that State were attacked by Hymenopterous parasites, and Mr. Koebele was notified of this fact by the chief of the entomological staff at Washington. Mr. Koebele's investigations resulted in the discovery of many such parasites, belonging to the family Dryinidæ. The appearance of these parasites is well exemplified by the "Fairchild parasite" *(Echthrodelphax fairchildii)* of the cane leaf-hopper, now so familiar to most Hawaiian cane-planters.

In addition to these Dryinidæ, the little Mymarid egg-parasite of Liburnia *(Anagrus columbi)* was discovered, and also the common presence of the minute Stylopids of the genus *Elenchus* and others. Finally there was procured a single puparium of a Dipterous parasite, from which no mature insect was bred, but it unquestionably belonged to a species of *Pipunculus*.

The immediate and actual results of Mr. Koebele's consignments of North American insects were, on the whole, disappointing. Neither from a purely scientific point of view, however, nor from a practical standpoint, was this material done justice to. I wish to lay particular stress on this point, because it shows at once the frequent value of work of a highly technical nature for practical purposes, even though it may be largely incomprehensible to any save an entomologist, and even to any save an advanced student of entomology. When Mr. Koebele's living specimens came to hand, I was fairly well acquainted with the published facts already known about these leaf-hopper parasites. This published information, however, was of the most meagre description, apparently only three or four of the great numbers of known species having been bred or having had their habits studied. Further, of those which had been bred, in most cases only a few individuals had been reared and information as to diversity or uniformity of habits was almost wanting. In one case only, one of these parasites had been recorded as attacking two species of leaf-hopper, and those so utterly different in all points of structure, as to lead one to suppose that the Dryinidæ might be indiscriminate in their choice of host. I refer to the case of *Labeo typhlocybæ* and *Dryinus ormenidis.* We now know that, in reality, these parasites generally are most particular as to their choice of host, and those which attack leaf-hoppers of the Delphacid group, to which our cane-hopper belongs, do not even extend their attacks to species outside this group, still less will they attack such different hoppers as are included in the great Jassid series. Now the living material sent to me by Koebele from North America included parasites of many small leaf-hoppers, belonging to most diverse groups, many of which would never have attacked our cane-hopper, as their structure plainly shows. It was not until I was in Australia and had leisure to examine Australian parasites with some care that I discovered the microscopic characters, which are always found in those species which attack leaf-hoppers of the Delphacid group, as opposed to those preying on Jassids. For want of this knowledge, Mr. Koebele's material from North America was, as I have said, not done full justice to from a practical point of view; much time being wasted on parasites that never would have attacked our cane leaf-hopper. Still at least two species of imported North American Dryinidææ did attack our cane pest, and were reared on these in captivity, and their offspring liberated in the cane-fields, but neither of these has as yet shown up at large.

That Mr. Koebele's North American material has not been done justice to from a purely scientific point of view is due to the fact that the practical end in view, namely, to establish the parasites, naturally outweighed the former. There are ten North American species described or referred to in Pt. I of this Bulletin, but the number really collected and sent by Mr. Koebele was unquestionably considerably larger. With the exception of one or two species sent in great numbers by him, no individuals were killed by me as specimens for study. Some were turned loose in cane-fields, infested with leaf-hopper, and some were placed in large cages on growing cane plants similarly affected. The preserved material therefore chiefly consists of specimens that died a natural death in these cages, and which happened to be found subsequently, together with a few examples that emerged and died on the way to the islands, and, again, of a few examples collected and mounted by Koebele himself in Ohio and California.

From another point of view Mr. Koebele's work in Ohio and California was of great value, for it was extensive enough to show what kind of natural enemies of leaf-hopper might be looked for in other countries. In fact it was these prior investigations in North America that led him at once to investigate the eggs of the cane leaf-hopper in Australia for internal parasites and to at once discover their presence on this investigation.

MISSION OF KOEBELE AND PERKINS TO AUSTRALIA.

We reached Sydney in May, the weather being cold and on our first arrival very wet, so that little entomological work was done there. Mr. Koebele, however, wished to visit some of the orange orchards in the vicinity, with which he had become well acquainted on some of his earlier missions. A number of species of living ladybirds were accordingly collected and shipped to Honolulu. Being too far south for cane, not much attention was paid to leaf-hoppers, but the presence of hymenopterous parasites was demonstrated by the discovery of Dryinid sacs on the larvæ of common Jassids.

Early in June we arrived at Brisbane, and on the first cane that we saw, a few plants in the public gardens, we at once observed the presence of the cane leaf-hopper. A short stay of about ten days gave ample proof of the existence in Australia of a considerable variety of Hymenopterous parasites of leaf-hoppers, of Dipterous parasites of the genus *Pipunculus,* and of Stylopid parasites of the genus *Elenchus.*

At Bundaberg, about twelve hours by rail north of Brisbane, we spent another ten days in June. Here is an extensive cane district with our leaf-hopper everywhere present, but never in numbers such as we are accustomed to in these islands. In fact we never saw the hoppers nearly as numerous as they are on our least affected plantations. From eggs collected here Mr. Koebele soon bred out specimens of the Mymarid parasites he had felt so confident of finding.

From our observations on the habits of the cane leaf-hopper in these islands, it seemed probable that in tropical Australia this species would be in its greatest numbers in the colder months, so after a brief stay in Bundaberg, we proceeded north to Cairns, which place we reached at the beginning of July. This plan seemed very expedient, for, by retreating gradually towards the south, as the hot season advanced, we hoped to prolong the season during which natural enemies for the cane leaf-hopper could be obtained. It appeared likely that effective work could only be done at Cairns for a month or two, since without a reasonably large supply of hoppers, it was evident that the parasites could not be found in sufficient numbers for shipment. This indeed proved to be the case, and by the end of August, leaf-hoppers and their eggs had become so scarce in the cane-fields, that we came south again to Bundaberg. At Bundaberg we made a long stay on this occasion, regularly sending off consignments of parasites, until here too, owing partly to the season and partly to the harvesting of the crop, the locality became unprofitable. After a short stay in Brisbane, at the end of the year, I returned to Honolulu, while Mr. Koebele proceeded to Sydney, where his attention was largely given to collecting beneficial insects for pests other than leaf-hopper. On the return journey Mr. Koebele spent one month in Fiji, the enemies of the cane-hopper in those islands being mostly similar to those already found in Australia. A fine consignment of the Chalcid egg-parasite *(Ootetrastichus)* of leaf-hopper was most important, as it enabled us to establish that important species without any doubt.

MODE OF SENDING OVER PARASITES.

During the earlier part of our Australian trip all beneficial insects sent from Cairns were placed in cold storage. The fact that the coast steamers generally failed to make close connection with those leaving Brisbane or Sydney for Honolulu, and the necessity for reshipment and removal from the cool chamber, made it a matter of great difficulty to get any insects over alive. Of some predaceous species, however, such as certain ladybirds and some others, a small percentage of some species survived their long journey. These were packed in the way usually adopted by Mr. Koebele, in specially made wooden boxes nearly filled with slightly damped *Sphagnum* moss. The sides and bottoms are dove-tailed and hold well together in spite of the great dampness of the cool chamber. These boxes are made in three sizes, nesting within each other, the largest $4x3\frac{1}{2}x2\frac{1}{2}$ inches, the smaller $3\frac{5}{8}x2\frac{5}{8}x2\frac{1}{8}$ inches. When filled each is securely bound with strong string and the whole made up in one parcel for shipment, being wrapped in several sheets of stout packing paper.

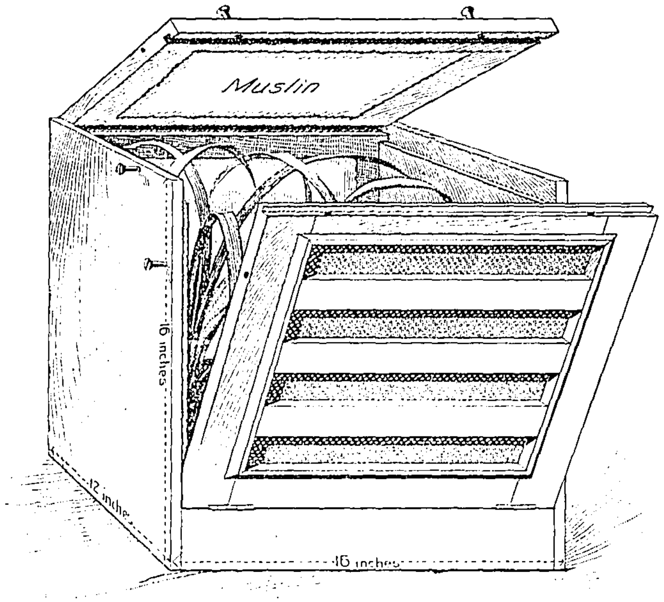
With the very minute and delicate egg-parasites of the Eulophid and Mymarid families, which we were most anxious to get established in the islands, various methods were used. The cuttings of the midrib of cane-leaf containing eggs of leaf-hopper were made as short a time as possible before the steamer sailed. That they contained numerous parasites was certain from the samples we always retained to be sure on this point. Though these samples were always very small compared with the amount sent, yet we never failed to breed many parasites. Some of the cuttings were packed in the wooden boxes above described with moss, some in similar boxes with powdered charcoal, and some in tin boxes. It does not appear, however, that from the four consignments sent from Cairns, which must have included great numbers of parasitized eggs, that any of these parasites reached Honolulu alive.

Our subsequent consignments, from Bundaberg, were more successful, as was natural, the ports of departure of the Honolulu steamers being so much nearer. Cuttings of cane leaves containing leaf-hopper eggs sent from here produced both Eulophid and Mymarid parasites on arrival in Honolulu, and in fact some individuals of most of the Bundaberg species, that we desired to establish, reached the islands alive. Thus two of the

Dryinid parasites of *Siphanta* (a *Paradryinus* and a *Neodryinus*) were bred in numbers in Honolulu, and liberated for the purpose of attacking the introduced pest *Siphanta acuta*. Further, two of the small wingless species of the Dryinid family, belonging to the *Gonatopus* group, were likewise successfully imported, and one of these was successfully bred up in captivity on the cane leaf-hopper. A Proctotrupid parasite *(Aphanomerus pusillus)* that destroys the eggs of the *Siphanta* above mentioned, was also successfully imported, and is now well established at large in the islands and is already destroying a large percentage of the eggs of that leaf-hopper. All these were sent over from Bundaberg in cold-storage, the Dryinidæ as larvæ in the cocoon or pupæ. Although eventually egg-parasites of the cane leaf-hopper were obtained from sections of leaf containing the eggs, sent in cold storage, yet it was, as has been shown, only after many attempts had proved unsuccessful. At one time it seemed as if the prolonged cold temperature of (supposedly) *from 40°-45° F. was fatal to every parasite, and so far as we know, it was so in the case of all those sent from Cairns, but not always to those from the less distant Bundaberg. This led me to suggest that we should have some special cages made, somewhat similar to those Mr. Koebele had previously employed in shipping stylopized leaf-hoppers from North America, in which living cane could be grown and the cages themselves sent on the open deck, allowing the delicate egg-parasites to emerge and reproduce in transit. For minute and delicate parasites, inhabitants only of tropical countries, there is very little doubt in my mind that this method of transportation surpasses all others. In fact the two first cages sent in this way, each stocked with a different species of Mymarid, both yielded parasites after their arrival in Honolulu. These cages were built very strongly and with considerable care, special precautions being taken by simple devices that everything fitted compactly and that light was entirely excluded at all joints and that escape of any insects would be impossible. The adjoining figure shows the construction. The top and front are both hinged, so as to be capable of being fully opened out; in the back and front are cut openings of 9 inches by 11; these openings being covered on the inside with fine strong white muslin fastened with shellac, and on the outside, as a protection, with a sheet of strongly perforated zinc, which itself is still further protected by transverse wooden bars. Although in such a cage the light is necessarily largely cut off, yet grass or cane plants will grow therein for weeks, though the leaves may become chlorotic. As a matter of fact, we chiefly used pieces of cane-stem planted in almost pure white sand, for these will root

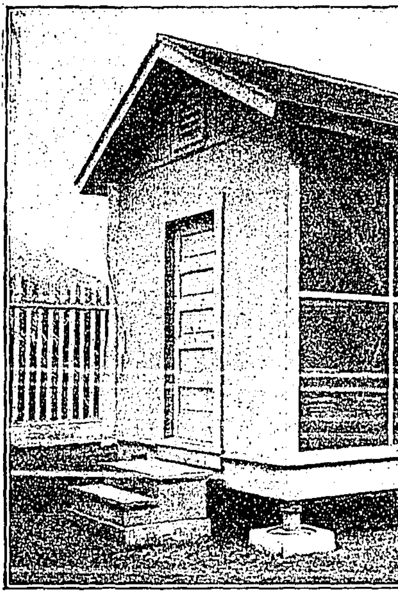
* A temperature of 28°-32° for two weeks was fatal to every egg of the leaf-hopper and to the parasites.

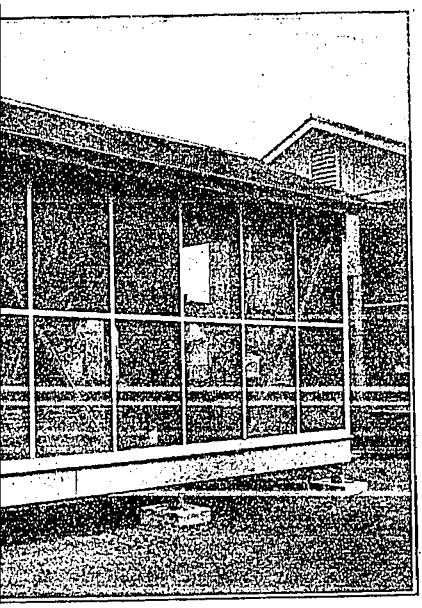
and the eyes sprout quite successfully under such conditions. A removable zinc tray fitting the bottom of the cage holds the sand or soil. For the journey this tray was securely fastened down by a couple of small nails.

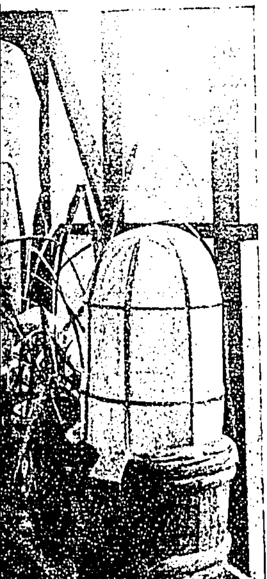


HANDLING OF BENEFICIAL INSECTS AFTER ARRIVAL.

The successful handling of the various parasites and predaceous insects after their arrival was of course all important. The latter are generally of a much hardier nature than the former and any one at all accustomed to raising broods of insects can successfully propagate such creatures as ladybirds in captivity, provided that their proper food is procurable and climatic conditions permit. It is clear that for practical purposes the discovery of a parasite of an injurious insect counts for little (except for such scientific value as it may have) unless it can be

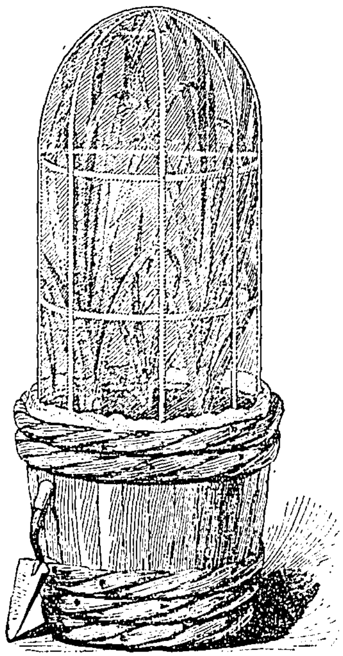




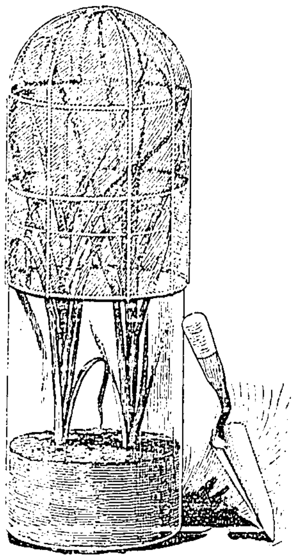


transported alive to the country where it is needed, and again the discovery and successful transportation alike count for nothing economically, unless it can be established at large after its arrival. It is no doubt in many cases decidedly more easy to discover natural enemies of an insect pest than it is to establish them in a new and distant country. We have heard some, who profess to be in favor of the repression of injurious insects by means of natural enemies, talk of the discovery of a parasite, as though the fact of this discovery were all important, whereas we must repeat that unless the parasite can be successfully introduced and established and duly performs its share of work in controlling the pest, the discovery is of insignificant importance. Further, cases where a single natural enemy is alone sufficient to keep down an injurious insect are rare and exceptional, and few pests are to be kept down in this way. As a rule, it is a complex of causes that keeps an insect in check, often the joint attack of various parasites and predators, and it may be various diseases and other conditions combined. Only in exceptional cases can the economic entomologist hope to succeed with a single parasite, as any practical field worker must know. When beneficial insects, parasitic or predaceous, have been successfully imported, no methods by which they may be successfully established should be neglected. Predaceous insects are generally comparatively large and hardy, and can be safely liberated where their food is abundant. Parasites on the other hand are often excessively minute and delicate and may require the most careful handling. As a rule, should some species that it is desirable to establish be received in any numbers, it is always safer to divide them, and adopt various methods. It may be safely said that in nearly all cases (unless climatic conditions are altogether unfavorable) half the specimens received should be at once liberated in a suitable locality. Some minute Chalcids and other parasites are very easily bred in captivity, but this is by no means always the case. In rearing insects in captivity in tropical countries, there is one absolute essential, which is perfect isolation from ants and other carnivorous creatures. Several years ago, I had built for this purpose a small house isolated from the ground, the supports resting in water or water covered with a layer of kerosene oil.

Similar houses are in use at our Experimental Station (see cut). It is necessary to take care that grass and weeds do not grow up so as to form a connection with the house; and, as will be noticed in the figure, the steps are built separately, and do not actually touch the house. The sides of these houses are covered with copper wire and in stormy weather blinds of thick white canvas can be let down for shelter from the rain, or on other days as a screen from excessive sun. The wire-mesh is fine enough to prevent the escape of a moderate-sized lady-bird. The earth used for plants in these houses is soaked in boiling water to kill ants and other injurious insects that may be present in any stage, and the wooden tubs, in which the plants are grown, are similarly treated. These tubs of Japanese make (manufactured as containers of the Japanese drink "saki") often afford hiding places to centipedes, cockroaches, ants and other most undesirable insects. On one occasion some years ago, in one night I lost a whole brood of about sixty individuals of a beneficial insect, that I wished to establish, from the attack of a small centipede accidentally carried into a house in a saki-tub, that had not been treated with boiling water. These saki tubs, as shown in the adjoining figure, are excellent for growing cane or other plants, which can be covered with a cap of fine muslin, fastened on a light bamboo-frame with shellac varnish. Either by a small door or a mere hole, which can be closed with a plug of cotton, the injurious insects and their parasites can readily be turned into such a cage and allowed to breed there.



In establishing the minute parasites that destroy the eggs of leaf-hoppers the following procedure was adopted. I will take the case of *Paranagrus optabilis*, whose life-history I have detailed in Pt. VI of this Bulletin, as the same treatment was given to all the other minute parasites. Eight examples of the *Paranagrus* were bred from Queensland cage between January 17th and 30th. Four were liberated in the Experiment Station grounds, four were transferred to a glass-jar containing a young growing cane, in the leaves of which leaf-hopper eggs had previously been deposited. The jar used was a large glass batteryjar (the size is well shown in the adjoining figure by comparison with an ordinary garden trowel lying against it) containing very young cane plants. Round the jar near the top is bound a band of cotton or other material, on which rests the cap formed of muslin fastened over a fine bamboo framework with shellac.

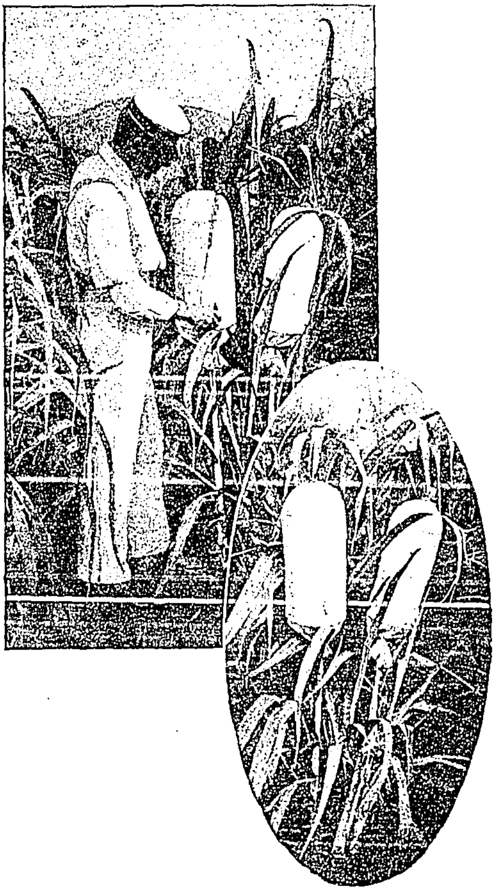


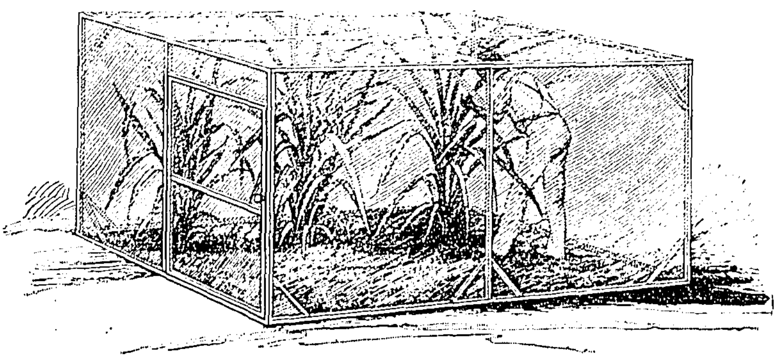
These caps are remarkably convenient for handling delicate parasites. When one wishes to collect from the jar, by wrapping the whole in a black cloth and leaving only the top of the cap uncovered, after first dislodging the parasites from the plants by striking the jar with the bare hand, these will at once fly to the top of the muslin cap. The cap is then removed and laid on its side, the closed end or top being held towards the light, and the parasites can be collected in glass tubes with the utmost ease as they seek to escape at that end.

At the end of three weeks the first brood of parasites began to appear, and in all 47 individuals, all females, were obtained. Half of these were liberated, the rest being used to stock a number of new breeding jars similar to the one described. From these a very large number of individuals were reared, and these were treated in various ways.

Some were "sleeved" out in the fields on growing cane much punctured with hopper. These muslin sleeves stretched on light bamboo framework are shown in the adjoining figures, the parasites being introduced through a small hole at the lower end, by means of a glass tube. A plug of cotton closes the hole, after they have been turned in; while in wet weather a cap of waterproof cloth can be fastened over the upper part of the sleeve to afford shelter.

In the breeding-houses large colonies were now raised on larger cane-plants in the saki tubs already mentioned; and other still larger ones in the open field beneath light portable cages, which could be placed over several entire well-grown cane-plants, and were of sufficient size to allow one to enter and examine the condition of affairs within, and to make cuttings for further distribution. These large light cages were further screened on the windward side by a strip of heavy white canvas, to break the force of the wind. All these methods were entirely successful,





not only with the Mymarids, but also with the more sturdy egg-parasite of the genus *Ootetrastichus.*

While the parasites were still comparatively scarce and not easily obtainable in numbers for distribution, they were sent out in colonies, in the glass battery-jars already figured, to such plantations as stood in most immediate need. To the various plantation agents was left the choice, as to which of their plantations should be first supplied.

Subsequently as the cane in the experiment station became well stocked with parasites, it was only necessary to take cuttings of the midribs of cane leaves well filled with eggs and send them to the plantations in a very simple form of cage. Prior experiments had proved that from such leaves parasites would continue to emerge daily for at least two weeks after the cuttings were made. All that it was necessary for the recipient to do was to hang the cage in a suitable spot, the large number of parasites that would emerge from each cage making it almost impossible to fail in establishing them. The emergence of numbers of individuals day after day rendered the occurrence of unfavorable weather (which is so frequently a cause of failure in establishing beneficial insects, when liberated at one time as adults) a matter of small account.

EFFECT OF VARIOUS NATURAL ENEMIES IN CONTROLLING LEAF-HOPPER.

Having dealt with the introduction, propagation and distribution of the several parasites, we will now consider the practical effect of these and other natural enemies in diminishing the leaf-hopper pest. They are yet in Australia and Fiji, as can be seen by the student of the various Parts of this Bulletin, a number of other natural enemies of leaf-hoppers, which, introduced, would certainly attack our cane leaf-hopper, though either we did not attempt to introduce these, or were unsuccessful in the attempt. I have already, in my last annual Report to the Committee on the Experiment Station, stated what parasites we especially desired to import and the reasons for this, but for the sake of completeness, I here make some repetition. Thus in choosing what natural enemies it was desired to introduce, we had to consider: (1) their effectiveness or importance as destroyers of the pests; (2) the possibility of successful transportation; (3) the probability of their thriving in a new country; (4) the rapidity of their increase, when established. On the first two heads, there is nothing special to remark, but the third was a matter of great importance. When one considers the excessive difference in climate between many of the plantations, the extremes being shown by one where cane is grown on the windward side at an elevation of about 1500 or more feet, with its excessive rainfall, and one nearly at sea level on the dry leeward side, where cane can exist only by constant irrigation, it is obvious that comparatively few species of insects can be expected to thrive equally well under such diverse conditions. Consequently we had need primarily of parasites of wide-spread range in their own country, not such as were of local occurrence only.

The fourth consideration, that is the rate of increase, was to us of the greatest importance, since we had to deal with a pest already established for years, and that had no doubt reached its average numerical maximum throughout the islands. In this the little Mymarid egg-parasites of the genera *Anagrus* and *Paranagrus* excel. They complete their life cycle in about three weeks in these islands, and apparently breed at the same rate, or nearly so, at all seasons of the year. Further they are largely parthenogenetic, the male sex being only produced at rare intervals.

The Tetrastichine egg-parasite *(Ootetrastichus)* on the other hand is a comparatively slow breeder, taking fully twice as long as a Mymarid to complete its life-cycle, or longer still. It, however, probably produces twice as many eggs as the other and is, so far as is known, entirely parthenogenetic, no male having ever been seen. If we judge the effectiveness of the two parasites merely on rate of increase (reckoning the life cycles as 20 and 40 days rspectively), and suppose that the Mymarid produces 20, the Tetrastichine 40 female young, at the end of six months the latter will have produced four thousand and ninety-six million descendants, but the Mymarid in the same time will produce more by one million times. In reality no case is of this simple nature, the habits and constitution of the parasites have to be considered. Thus the Mymarid is much more delicate than the other, and liable to be decimated by storms, but it lays its eggs within a very short time of emergence, while in *Ootetrastichus* the period of egg-laying is extended over weeks. The latter, besides its robust nature, has this advantage, that each individual is bred at the expense of *the whole contents* of an egg-chamber of the leaf-hopper, while of the Mymarid each individual is bred at the expense of only a single egg.

If we consider the effectiveness of the four egg-parasites, *Paranagrus optabilis, P. perforator, Anagrus frequens,* and *Ootetrastichus beatus, in areas where all are well established,* we must rate the first-named as *at present* by far the most effective. As I have previously pointed out, this species is capable by itself of destroying about 50 per cent. of the cane-hopper's eggs and *Anagrus frequens* and *P. perforator,* extraordinarily numerous as they appear, where seen alone, are but as isolated examples in the crowd, where all are well established in one spot. The *Ootetrastichus* slowly but steadily increases in numbers, and on many plantations I expect that it will ultimately be the most efficient of all parasites. I do not think that it can show its full value till 1908, for each harvesting of the cane crop is necessarily a very great setback to its natural increase. *Anagrus frequens,* under which name are probably more than one species, or at least one or two distinct races of a single species, although it appears at a disadvantage, when in company with *Paranagrus optabilis,* is nevertheless a most abundant parasite. In Part VI of this Bulletin I have compared the habits of the two and need not refer to the matter here, but I may say that as many as eighty or a hundred exit holes of the *Anagrus* have been counted in a single cane-leaf, so that its great utility is unquestionable. *P. perforator,* common in Fiji, attacking eggs of hopper laid in thick stems of grass, more rarely those in cane, will probably gradually wander away from the cane-fields to attack the eggs of native hoppers, that are laid in stems and twigs, as it now chiefly attacks the cane-hopper eggs when these are laid in the stems.

Nor must it be forgotten, what valuable aid these egg-parasites receive in the control of leaf-hopper from other insects parasitic and predaceous, native or introduced. In fact, had there existed previousy no restraint to the multilplication of the pest, no one who has paid the least attention to such matters can doubt that it would some time since have become impossible to raise any crop of sugar-cane in the islands. The reason why these natural enemies have not alone got the upper hand of the hopper is due to various causes. In the first place, a number of the parasites such as the Dryinid *Echthrodelphax fairchildii* and the parasitic flies of the genus *Pipunculus* are of local occurrence, and in many places cannot (for climatic or other unknown reasons) maintain their existence. This was well shown by the behavior of the first-named, which was distributed in thousands by the entomologists and the plantation managers themselves to all the districts in the islands, but in many places did not thrive. Such, too, is the case with the predaceous black earwig *(Chelisoches morio)* which, a natural immigrant to the islands and no doubt acclimatised centuries ago, is found on comparatively few plantations. Other natural enemies are themselves periodically decimated by parasites, as is the case with the introduced green cricket *(Xiphidium varipenne),* which has its own egg-parasite *(Paraphelinus).* Other enemies like the common lady-bird *(Coccinella repanda)* introduced by Koebele years ago for other purposes, prey on young leaf-hoppers, in default of more favorite food, and this valuable predator too is itself subject to parasitic attack by the common Braconid *(Centistes).* At present the whole number of parasites and predaceous insects that attack cane leaf-hopper to such an extent as to render their services worth noting is considerable, as the following summary shows.

The most valuable are the four egg-parasites, which there is every reason to hope will become still more effective with reasonable time, one (*Ootetrastichus*) having as yet had no chance to show its full effectiveness.

The two Pipunculus flies (*P. juvator and terryi*) are restricted to certain localities and are native species, which have transferred their attacks from native Delphacids to the cane leaf-hopper.

The ubiquitous lady-bird (*Coccinella repanda*) is valuable as a destroyer of leaf-hopper, though originally imported by Koebele to destroy Aphis. It is hoped that other lady-birds, especially *Verania strigula* (=*V. lineola* of Pt. VII) may become established and do good work, as in Australia and Fiji, whence they were imported.

The earwig *Chelisoches morio* is a local species, but no doubt useful where it exists in numbers.

The green cricket (*Xiphidium varipenne*) is very valuable, but is most unfortunately heavily attacked at certain seasons by an egg-parasite.

The Dryinid *Echthrodelphax fairchildii* is locally valuable. At certain seasons in suitable, but limited, localities, it destroys a considerable percentage of hoppers. Its services are underestimated, because for a large part of the year it lies as a dormant larva in the cocoon, and parasitized hoppers at such a time are naturally hardly to be found.

There are many other natural enemies of more or less importance, e. g. the various predaceous Hemiptera, and the several lace-wing flies (Chrysopinæ).

In addition to these insect enemies, we must mention the two fungous diseases of hoppers (amounting locally and at certain seasons to epidemics) which, long previously known to kill the native leaf-hoppers, have become transferred to the introduced pest. We also found one or more fungous diseases attacking leaf-hopper eggs in Fiji and Australia in all localities. With material imported from these countries, I easily infected eggs of the cane leaf-hopper under cover, and subsequently established the fungus at large in the field. As it was most probable that parasitized and healthy hopper eggs would be affected alike by the disease, and consequently many of the egg-parasites would be destroyed, it became a subject of discussion whether we should attempt to estabish the fungus or not. As, however, throughout Australia, the fungus and parasite both attacked the eggs, Mr. Koebele was of opinion that we should try and establish the same conditions here. Consequently with the first cages sent to the plantations the cane cuttings and the cane itself were well sprayed with water containing spores of the fungous disease, so that these would be certainly carried abroad by the emerging hoppers and parasites. I imagine there is no doubt as to this disease becoming established in all suitable localities.

The question that one will now ask is: Are these parasitic and predaceous enemies combined sufficient to prevent any further serious damage from leaf-hopper? Though a natural one, it is hardly yet a fair question. The leaf-hopper was in numbers sufficiently great as to be injurious in 1900, and spread and increased greatly since that time. The distribution of imported natural enemies began about a year ago. Some of the best of these have been distributed much more recently still. To serve fifty or more plantations, many of great acreage and occupying many miles of country, with introduced parasites, must naturally take considerable time. One of our most important parasites, if it thrives here as in Fiji, as I have already pointed out, is at present hardly to be reckoned with. It should be of decided value next year, of much more the year after. It is merely a question of natural increase, for that it thrives here at large as well as in captivity is already proven. When one considers the enormous monetary loss, considering the size of these islands, that has been occasioned by the leaf-hopper. I do not think one should cease to seek natural enemies against the pest, until it is absolutely proven a pest no longer, however strong one's hopes may be that the present enemies are sufficient to cope with it. I have been told on the best authority and by those most interested, that the loss to these islands caused by the cane leaf-hopper since its first noticeable appearance in 1900 to the present time may be reckoned at millions of dollars, and one is justified in taking every precaution, where so much is at stake.

(To be continued.)

PRELIMINARY NOTES ON ROOT DISEASE OF SUGAR CANE IN HAWAII.

BY L. LEWTON-BRAIN.

(With 12 Original Illustrations in the Text.)

(*Continued from last Number.*)

EFFECT OF FUNGUS ON NUTRITION AND GROWTH.

The primary damage done by the root fungus being now understood, it remains to be seen what effect this has on the general growth and nutrition of the sugar-cane plant.

As has already been pointed out, it is at the growing point alone that the formation of new tissues takes place. The root hairs, which are the absorbing organs of the plant in the soil, are short lived, and, normally, are continually being replaced by new ones from cells produced at the growing point. When the activity of the latter ceases, this supply is cut off, so that in a short time the root has no functional root hairs; consequently the activity of that root in absorbing water is destroyed. In other cases, the growth of the root may be stopped before its root hairs develop.

As old sugar-cane roots reach their full development and then die, in the normal course of events, their place is taken by new roots developed from underground parts of the stem. When the root fungus is present and destroys the young roots as soon as they begin to grow, it is not long before the consequent reduction in the water-absorbing power of the root system begins to make itself felt. The water, with its contained food salts, is absorbed in gradually decreasing quantities; consequently less and less of these substances find their way into the leaves, there to be elaborated up into sugars, proteids, etc.

Apart from this, the plant keeps on trying to produce new roots to replace those destroyed by the fungus and so is continually drawing on the supplies of food elaborated in the leaves, while at the same time, as the supplies of raw materials from the roots are continually diminishing, the plant becomes less able to provide the supplies for their development.

EFFECT ON ABSORPTION AND GIVING OFF OF WATER.

It can now be seen why the first effect of root disease is seen in the rolling up and yellowing of the leaves. The leaves are, at this stage, in a normal state of activity and so giving off water vapor freely; the roots on the other hand are sending up less water than usual; the state of affairs is the same as that met with in times of drought and the plant responds to it in the usual way, that is, by rolling its leaves and so shutting off the free passage of the outer air over the breathing pores, so lessening evaporation. In this way a balance is struck between absorption and evaporation of water. The rolled up condition of the leaves becomes permanent, but the loss of absorptive power is a progressive one. In the next stage, the leaves do not get enough water to keep their tissues alive and so the ends and margins—the parts remotest from the water supply—begin to dry up and turn yellow.

EFFECT ON OTHER FOOD SUPPLIES.

The rolled up condition of the leaves is in itself not favorable to the nutrition of the cane. It is well known that green plants take in part of their raw food from the air in the form of the gas carbon dioxide. This, together with the other raw materials from the soil, is worked up through a complicated series of changes to sugars, proteids and other elaborated food materials. These changes take place in the leaves in sunlight and the resulting elaborated foods are conveyed to wherever growth may be going on or are stored in the stem for future use.

Now it is evident that any mechanism which lessens the amount of water vapor passing out of the leaves into the air, by checking the free interchange of gases, must at the same time lessen the amount of gases taken into the leaves from the air. So, the rolling of the leaves as a result of diminished water supply, has for one of its results the lessening of the food supply taken in from the air; this again results in a lessening of the sugars and proteids available for growth, and so root development, among other things, receives another check.

STARVATION OF SUGAR-CANE PLANT.

The whole process detailed above affords an excellent example of the way in which each part of the mechanism of the plant works in with every other part. Throw one part out of order and the whole mechanism is checked.

The starved appearance of a badly attacked stool of canes is now easily understood; it has its supply of raw food materials cut off at both ends and continually getting less, while the leaves are unable to supply elaborated food for the production of new absorbing organs.

The ease with which the plant is uprooted is, of course, due to the prevention of any development of roots, the anchoring organs of the plant.

It is now seen how every symptom of root disease can be traced back to the effect of the one primary damage done by the root fungus, the destruction of the growing point.

RELATIONS BETWEEN SUGAR-CANE AND FUNGUS.

A sugar-cane does not inevitably succumb to the attack of the root fungus in the manner I have described. It is a matter of experience that canes, showing symptoms of the disease, do sometimes grow their whole course without showing much material injury and may give a good yield; this is especially the case with plant canes growing under favorable conditions. Canes may even be noticeably injured by root disease and, if conditions change for the better, may throw it off and apparently entirely recover.

This is explained by the fact that the root fungus is not a strong parasite; it cannot enter, indiscriminately, any root tip and destroy the growing point, but a certain degree of weakness, a certain loss of vigor and vitality in the growing point, is necessary, before it can develop its parasitic powers and push its attack home.

On the other hand the sugar-cane, as may have been gathered, possesses considerable powers of resistance to the root fungus. When one root is destroyed another is developed to take its place and this can go on until the plant has exhausted its reserve of food materials. In fact, unless a shoot is attacked at a very early stage, it is rare to find one entirely killed by root disease.

The whole struggle between the root fungus and its host plant turns upon external factors, the chief of these being temperature, water supply, mechanical condition and fertility of the soil. If the conditions are such as to promote healthy, vigorous root development, the fungus is outgrown and its attack, at least for the time, thrown off. If, on the other hand, the temperature is too low, the soil contains too much or too little water, or is too closely packed, then root development receives a check and the parasite is able to overcome the resistance. Thus also, as conditions vary in an infected area, first checking, then favoring, root development, so in proportion does the progress of the disease vary.

Of course if the disease has already proceeded to such an extent as materially to reduce the plant's food reserve and check its growth, before conditions change to favor the host, recovery can only be partial and is often not noticeable.

RATOONS AND ROOT DISEASE.

The foregoing considerations will explain why it is that ratoon canes suffer more severely than plants from root disease. When plants start their growth, all the conditions are such as to favor the cane; the soil has recently been thoroughly cultivated and is in a good state of tilth suitable for root development. Moreover the cultivation by admitting air and sunlight has destroyed a certain amount of fungus mycelium in the soil; the temperature, if the cuttings are planted early, on the mauka lands, is high and continues so long enough to give the plants a good start; in dry districts special attention is paid to conditions of rainfall, so that in this respect, also, the plant cane gets as favorable conditions as possible.

The ratoon, even when perfectly healthy, is never so vigorous as the plant cane. Growth is always noticeably slower, both with the root and shoot system, so that root fungus, which entirely depends on the vigor of its host, has a better chance. Again, cultivation cannot be so thorough for ratoons as it is for plants; at best it can only result in a stirring and aeration of the surface soil; consequently the lower soil will be much closer and harder than when thoroughly cultivated, which again will prove a check on root development and so aid the fungus in its attack. Another point is that the mycelium of the fungus, during the growth of the plants, is allowed to grow unchecked and so increases largely in the soil and especially about the base of the stool where it is not disturbed by cultivation; the result of this is that as soon as the ratoon roots begin to develop the fungus is already in a favorable position to attack them. The conditions, then, for ratoons as compared with those for plant canes are, on the other hand, less favorable for the cane and, on the other hand, more favorable for the fungus. In the West Indies the difference is even more marked, as the climatic conditions, also, are far less favorable for the growth of ratoons, which start their growth in the dry season.

IRRIGATED AND NON-IRRIGATED PLANTATIONS.

The same considerations explain why it is that irrigated plantations suffer less from root disease than the non-irrigated. The water supply is always abundant and, so, one of the most important conditions is always favorable to the cane; when the attack begins the unaffected roots have always a plentiful supply of water to draw on and consequently the general nutrition of the plant does not suffer so soon, as the cane is in a better position to replace the roots destroyed by the parasite.

MODE OF LIFE AND SPREAD OF THE ROOT FUNGUS.

Fungi may be divided up into groups according to the way in which they obtain their food supply. Some of them can only take it from living hosts and cannot live on dead organic matter; these are the strict parasites. Others, again, can only take their food from dead animals and plants and cannot enter living tissues to obtain nourishment from them; these are the strict saprophytes. A third group can live and grow indefinitely, taking their food from dead matter, but can also under certain conditions enter the tissues of living plants and take their food from these; this group comprises the facultative parasites. To the third group belongs the root fungus; it lives and grows on the dead trash at the base of the cane; it grows on dead roots and stems below ground and can go on indefinitely living and spreading in the soil so long as there is sufficient dead organic matter present. It is this that makes it a difficult pest to get rid of. When a plant cane throws off its attack and sends out vigorous roots that cannot be destroyed, the fungus is not killed off, it lives on at the base of the cane, on dead leaf-sheaths, dead roots, etc., and so maintains its existence as a saprophyte, until conditions change and it is able to assert its parasitic nature. This generally happens, for instance, when the cane is ratooned.

There are two main sources of infection to be noted in considering the spread of root disease: first, diseased cuttings and, second, the soil. I have already shown that the leaf-sheaths on the lower part of the stem are infected with the fungus mycelium, not only so, but also that the developing roots some distance above the soil are also infected. If a cutting from this part of an attacked cane be planted, even though the leaves be stripped off, the fungus is planted too, and under the favorable conditions of darkness and moisture commences its growth with the cane. It can now spread, from the infected cutting as a center, through the soil, living on the organic matter there, passing from one cane to another, until a whole group of canes is attacked.

In many cases the soil is infected before the canes are planted; the fungus mycelium lives on any dead plant remains there, but especially on the dead cane stumps, if left over from last year's crop. In such a case the fungus mycelium in growing through the soil soon comes across the young cane plants; if the roots be growing feebly they will be attacked and destroyed; if the young roots be vigorous the fungus will grow on any old roots or other dead parts below the soil, will pass from these to the lower leaf-sheaths as these begin to dry up, and so establish itself around the base of the plant. In this way a whole field of cane may easily be attacked. The struggle begins between host and parasite with varying results as conditions favor one or the other.

TREATMENT.

A consideration of the life history of the root fungus and the relation between it and its host plant leads on naturally to the methods of dealing with the disease. It cannot be expected that the disease can be entirely eradicated, but, with a knowledge gained from a study of the fungus, it is possible to suggest treatment that will materially reduce the amount of disease and keep the fungus well in check. The treatment naturally falls under two heads—first, that which will weaken or destroy the fungus in the soil or on the canes; second, that which will encourage the growth of the cane and increase its vigor so that it will be better able to withstand the attack of the fungus.

CULTIVATION.

The cultivation of the soil is a treatment that works both ways. By loosening and generally improving the condition of the soil, with the consequent aeration, this is rendered better adapted to the healthy and vigorous growth of the root system of the cane. On the other hand as the soil is stirred up, the fungus mycelium, which would otherwise have been sheltered in the earth, becomes exposed to the action of air and sunlight, and in this way becomes weakened and a large proportion of it killed. The result is that the chances of the root systems of the next canes to be planted in the soil becoming attacked are greatly reduced and this apart from their own more healthy condition which renders them again less liable to be injured by the attack.

Ratoons, in these islands, receive a certain amount of cultivation, chiefly surface cultivation between the rows. This, by admitting light and air to some extent, checks the growth of the fungus. In wet districts, deeper tillage would probably be of even greater value in dealing with root disease. In dry districts, anything more than surface cultivation, to a depth of a few inches, is likely to do more harm than good; by a deeper cultivation, the capillarity of the soil is reduced and the root system disturbed, neither of which consequences would be of so much importance in a wet or irrigated district. Surface cultivation by breaking up the capillarity of the top layers of the soil, of course, conserves the moisture in the deeper layers. This, at any rate, is the result of the experiments with root disease in the West Indies.

DISTANCE OF PLANTING.

A suggestion made by Mr. C. F. Eckart may prove of great value in dealing with root disease. This is, briefly, the wider planting of cane on infected land. In this way, by having the rows, say, six feet apart instead of five, more light and air will be admitted between the rows and around the bases of the canes. The healthy effect of light and air, both as regards the growth of the cane and the destruction of the fungus mycelium, has already been laid stress upon. At any rate the suggestion is well worth a trial on infected land. It may be pointed out that wider planting does not necessarily mean smaller crops; there will be fewer plants, but these may be larger individuals.

ISOLATION OF DISEASED CANES.

Sometimes root disease appears in small patches in a field the rest of which is unaffected. If these areas be located in time, it is possible to isolate them and prevent the disease spreading any further through the soil in the manner previously described. This is accomplished by digging a trench around the infected spot, of greater depth than that to which the cane roots descend, that is about a foot to eighteen inches. It must be remembered that the fungus mycelium will have spread further than the area in which the disease is noticeable; the trench should, therefore, be made to include one or two rows of cane that are apparently healthy. The soil dug out should be thrown inside the trench, as throwing it outside this would be infecting healthy soil with fungus mycelium. In cases where this treatment is practicable it is a very good method for confining the disease to a limited area.

SELECTION OF CUTTINGS.

The use of diseased cuttings has already been mentioned as one of the ways in which the fungus is spread and carried to previously uninfected localities. It is therefore necessary to use the greatest care not to plant cuttings infected with root disease. It would be obviously wrong to plant cuttings from the lower part of the stem with the matted leaf-sheaths and fungus mycelium on them. Even if the sheaths be stripped off, I have shown that the fungus is still present in the developing roots. In dealing with fungoid diseases it is always advisable to leave a fairly wide margin for safety; the mycelium is always found to spread beyond the parts where it is externally visible. Consequently it will be far safer not to use any cuttings from plants that show the external symptoms of root disease. If this be not possible cuttings should at least be taken from a part of the cane some distance above where the matting of the leaf-sheaths is visible. If diseased canes are used for propagation, not only is there a risk of directly infecting the land, but, what is perhaps of greater importance, there is also risk of breeding up a race of canes susceptible to root disease. This is in exact opposition to all good agricultural practice, which is to breed exclusively from healthy stock and so increase its resistant powers to disease.

DISINFECTION OF CUTTINGS.

Mr. Eckart's experiments, detailed above, tend to show that the ill effects of root fungus on germination may be remedied by the treatment of cuttings with Bordeaux mixture before planting. This treatment requires further trial on a larger scale and on infected land; this cannot be carried out at the Experiment Station, but the experiment must be tried on a plantation which has some infected land. The best method would be to run two or three rows of treated cuttings right across and infected field, the remainder of which should be planted with untreated cuttings. Full details of the plans of the necessary experiments cannot be entered into here, but all possible advice and assistance will be given by this Division to any plantation manager who is willing to undertake the tests.

The treatment of infected soil with fungicides is not only a very difficult and large undertaking, but has proved in the West Indies, to be ineffectual in dealing with root disease of cane.

RATOONS.

The question whether plant canes affected with root disease should be ratooned is not a simple one and must be decided largely by local conditions. If external conditions are favorable, a ratoon crop may withstand and grow away from the disease to a great extent. On irrigated plantations, for instance, where the water supply is constant and abundant it may be advisable to ratoon. It is only under exceptional conditions that this is advisable in other cases; the ratoons are sure to suffer more than the first crop canes and, if conditions are at all unfavorable to growth, the fungus, established in the soil and around the cane stools, will have every chance to ruin the crop.

If, then the plant canes suffer at all noticeably from root disease, they should never be ratooned. If the attack on the plants is only slight the question must be settled by local conditions. From a purely pathological point of view it is never wise to ratoon an infected cane; as during the growth of the ratoons the soil will be more and more thoroughly infested with the fungus mycelium and so will be in a worse condition for the succeeding crop. The economic point of view is necessarily more complex.

DESTRUCTION OF DISEASED MATERIAL.

One of the surest ways of increasing the amount of fungus in the soil, is that of leaving in it the remains of canes which are infected with the mycelium. It is every bit as important in combating plant diseases to destroy infected material, as it is in dealing with human diseases.

If the old cane stumps are left to decay in the soil, the fungus mycelium will continue to live on them indefinitely and will be just in the right condition and position to attack any cane roots in the neighborhood. The stumps in fact give the fungus a base from which it can spread to living canes.

In plowing over diseased fields it will be well to make a special point of having the shares guided so that they turn to the surface nearly all the old stools; if no special attention be paid to this many of the stools will be covered up and left in the soil, there to propagate the disease.

The infected stools should be thoroughly destroyed. When practicable the very best method of doing this is to burn them. In other cases it may be less expensive to remove the stools to land that will not be planted in cane, mix them with quick lime, cover them with soil, and allow them to decay where there will be no chance of their infecting other canes. The same treatment should be applied to any other infected material, the matted leaf-sheaths, for instance, at the base of the cane.

LIME.

When the cane stumps are removed, there will still be left a certain amount of fungus mycelium in the soil. This can be destroyed to a great extent by the use of lime. The lime should, if possible, be unslaked, as in that state it has far greater fungicidal powers. It should be applied before plowing and along the rows where the cane has been growing, as it is there that the fungus mycelium will be most luxuriant. The quantity to be applied must depend upon local conditions and the extent of the disease; probably never less than 1,000 lbs. per acre should be used for this purpose.

STRIPPING.

The removal of the matted lower leaf-sheaths has been found in some cases to lessen the damage done by root disease. Taking away these infected coverings from the developing roots at the base of the cane must necessarily diminish the chances of these roots being infected as they emerge. Not only so but the admission of air to the lower parts of the cane will tend to improve their health, apart from the question of infection. The stripping should be commenced as soon as the matting of the sheaths is noticed and should be repeated as soon as it becomes evident again. Of course the stripped trash should be destroyed in the same way as other infected material and not be used to spread the disease to other cane.

RESTING INFECTED LAND.

Land that has become so badly infested with root disease that it is impossible to raise a fair crop even of plant canes upon it can often be improved by resting it from cane cultivation. During this period, which should be quite extended if it is hoped to starve out the root fungus, the land should not be neglected or allowed to become overgrown with weeds. In fact one of the chief advantages of resting, is that it gives the opportunity for a very thorough cultivation of the soil. The land should be plowed as often as can be managed, the furrows being run in different lines each time, so that fresh lots of fungus mycelium are turned up and exposed to the destructive action of the sun and air. A good dressing of quick-lime applied before plowing would materially aid in destroying the fungus.

While the land is resting, of course, fresh supplies of plant food are being rendered available for the uses of the cane. There is, on the other hand, danger, in districts with an excessive rainfall, of food salts being washed out of the soil, which will thus be in a worse condition for growth at the end of the fallow than it was before. To avoid this, green dressings of some leguminous plant might be grown and plowed in; this, of course, will add organic matter, of which some of the mauka soils already have too much. There is a need here of some remunerative crop, which could be grown on badly infected lands for a year or two in rotation with the sugar-cane.

DRAINAGE.

Any condition of the soil which tends to hinder free root development favors root disease. Thus both excessive drought and excessive moisture are favoring conditions for the disease. Excessive drought on a non-irrigated plantation cannot very well be remedied, but the effects of excessive water can be lessened by paying attention to the drainage. This applies especially where the soil is at all retentive of moisture or where the soil is thin with a close subsoil. In such localities it would be worth trial whether the growth would not be improved by planting the cane on the ridges instead of in the furrows. This, I understand, is the practice adopted in some of the parts of British Guiana, where the soil is liable to contain excessive moisture.

RESISTANT VARIETIES.

It seems most probable that the abandonment of first Lahaina and then Rose Bamboo canes, on certain plantations, has been largely due to the extent which these varieties are attacked by root disease. At present the Yellow Caledonia variety appears to be markedly resistant and to flourish on lands where the other two varieties do not thrive. Yellow Caledonia itself is not immune to the disease. I have seen specimens of it showing unmistakable symptoms, although they had not suffered to any great extent.

The Yellow Caledonia possesses features which may explain its powers of resistance. It is, in the first place, a more vigorously growing cane, and particularly it has a more vigorous root system; it may thus be capable of outgrowing an attack to which the other varieties would succumb. It is also a more upright cane and parts with its trash more readily, both points of importance in preventing the fungus from creeping up the stems. Whether this explains the whole case or whether this variety has any more remote powers of resistance cannot be definitely decided until our knowledge of the internal economy of the cane is more exact and extensive.

It will not pay to rely entirely upon the resistant powers of Yellow Caledonia and neglect other methods of dealing with the fungus. If this be done and the fungus be allowed to continue unchecked in the soil, it may in time adapt itself as thoroughly to the constitution of the Yellow Caledonia as it has already to that of the Lahaina variety. In particular, care should be taken not to allow the Yellow Caledonia to deteriorate by planting diseased cuttings.

Some of the new seedling varieties now being raised at the Experiment Station, it is hoped, may show a high degree of resistance. This is a point that cannot be entirely settled at the Experiment Station; the tests for resistant varieties must be field tests carried out, when possible, on infected land. Every plantation manager who is carrying out tests with new varieties should make it a special point to note the comparative resistance of each to root disease (also to rind and other diseases) and include it in his report on the variety.

It is not to be supposed that every remedial measure suggested will be applicable to every plantation in these islands. Where such a variety of conditions exists the only thing that can be done is to suggest as many lines of treatment as possible and to leave each plantation manager to pick out those which, from his local knowledge, he considers applicable to his own particular conditions.

IDENTITY OF THE ROOT FUNGUS.

Specimens of diseased cane were sent in September, 1904, to the Bureau of Plant Industry of the U. S. Department of Agriculture at Washington where they were examined by Mr. Rorer, with the object of having the disease identified. A reply was received in March, 1905: the canes had received very careful examination, cultures had been made of the fungus and a microscopic examination made of the mycelium. The conclusion arrived at was that the cause of the trouble was other than *Marasmius sacchari*. One of the chief reasons given for this conclusion was that no clamp connexions had been found on any material, either in the mycelium on the canes sent, or in that obtained in cultures; while the clamp connexions had been specially noted in the mycelium of *Marasmius sacchari* both in Java and the West Indies; hence the stress laid upon clamp connexions in an earlier part of this paper. Another reason was that no fruiting bodies had been found.

As already mentioned clamp connextions have been found in material similar to that sent to Washington and one of them is shown in Fig. 9. This seems to remove one of the differences emphasized. It was not an easy matter to find the clamp connexions, they appear very sparsely and it was only after many days' careful searching, that an indubitable one was found. Neither Wakker nor Howard, in describing the disease due to *Marasmius sacchari*, mentions the scarcity of clamp connexions.

The other point, the absence of fructifications, by which alone a fungus can be recognized, is not so much a difference as a want of proof of identity. It must be remembered, moreover, that the Washington trials were made in a temperate climate in the winter, when conditions would hardly favor the fructification of a tropical fungus.

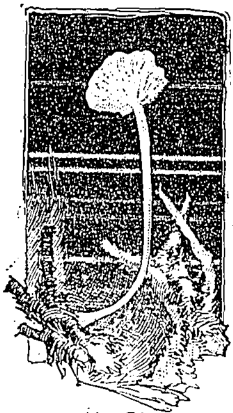


FIG. 12. Toad-stool of Marasmius sacchari, the root fungus of Java and the West Indies.

Note the stalk (springing from a diseased root) which bears the cap. On the under side of the cap note the gills on which the spores are produced. From a photograph of a specimen which had shed its spores and was partly dried up. Natural size.

These toad-stools are best seen in the early morning, as they dry up when the sun gets on them. They grow quite close to the base of the cane and are easily overlooked. No toad-stools have been found belonging to the Hawaiian root fungus.

Personally, I am strongly of the opinion that the two diseases are identical, and I have had the advantage of studying them in the field in the West Indies and in these islands. The matter can only be settled by obtaining the fructifications of the Hawaiian fungus, getting pure cultures from the spores and carrying out infection experiments.

It is certainly remarkable that no toad-stools have been found, and I should be very glad if any one would forward to this Division, any small toad-stools which are found growing on or near diseased canes. The appearance of those of *Marasmius sacchari* is shown in Fig. 12, drawn from a West Indian specimen. They are small, not more than an inch across and often smaller, the color is a dirty white. They are composed of an umbrella-shaped (sometimes flat) cap, supported in the middle by a thin stalk. The toad-stools are extremely delicate and soon dry up, so that the best time to find them is in the early morning. They usually are found near the base of the stem, springing either from dead roots or the matted trash. Taking all these points into consideration, they are not likely to be found without careful search. Specimens of toad-stools sent in for examination are best preserved in water containing 2 per cent of formaldehyde (5 parts of commercial formaldehyde to 95 parts of water); if this is not available they may be preserved in wood alcohol or other spirit; dry specimens wrapped in paper and carefully packed should also be sent.

Every effort is being made in the laboratory of this Division, to obtain the fruiting bodies of the root fungus. Hitherto, these have had no result. It is hoped to publish the results of culture and infection experiments as a separate bulletin when these are complete.

In conclusion, I have to express my thasks to Dr. N. A. Cobb, Director of this Division, and to Mr. C. F. Eckart, Director of the Division of Agriculture and Chemistry, both of whom have read this bulletin in MS., for many suggestions and much advice. The illustrations are the work of Mr. E. M. Grosse, of this Division.

SUMMARY.

Root disease is the most important fungoid disease of sugar-cane in the Hawaiian Islands. It is responsible for the abandonment of Lahaina and Rose Bamboo canes in certain localities. Its most marked effects are seen on ratoons.

The first symptoms of root disease are like those of drought. The leaves stand upright, roll up, turn yellow, and gradually become very dry; the leaf-system is much reduced. The lower leaf-sheaths become matted together and to the base of the stem. A white fungus mycelium is found among them. In Hawaii root disease is also noticed to affect germination.

The root fungus attacks the growing point of roots, so preventing their further development. As this continues, the water supply from the soil is reduced, this brings about secondary effects on nutrition, which react again upon root development. Finally the nutrition of the cane suffers severely.

The sugar-cane, growing naturally, possesses considerable powers of resistance to root fungus and is able to outgrow an attack.

Root fungus is essentially a soil fungus. It is able to live as a saprophyte on dead organic matter in the soil, and especially about the bases of the cane stools.

Treatment for root disease consists in, first, planting resistant varieties, as the Yellow Caledonia, the utmost care being taken to secure healthy seed. Cultivation and liming the soil tend to destroy the fungus there and are also favorable to the vigorous development of cane roots. Ratooning is, generally, not advisable. The destruction of diseased material should be as thorough as is consistent with economy. It is sometimes necessary to throw land out of cane cultivation on account of this disease; a remunerative rotation crop would be of great value here.

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SUGAR IN FRANCE.

SCHEME TO INCREASE PRICES BY DECREASING ACREAGE.

Consul-General Skinner, of Marseille, reports that in order to overcome the effects of overproduction the growers of sugar beets in France are being encouraged to reduce the area of cultivation. Mr. Skinner writes:

In order to advance the price of sugar, weakened by general overproduction, a systematic reduction of the cultivated area has been encouraged in France. The area sown with beets was diminished by 11,811 hectares (29,185 acres) in 1903, and in 1904 the total area sown was 203,772 hectares (503,529 acres) against 236,874 hectares (585,325 acres) in 1903, another decrease of 33,102 hectares (81,796 acres). The persistent dry weather of 1904 lowered the yield per hectare (2,471 acres) from 27,462 kilos (60,632 pounds) in 1903 to 22,915 kilos (50,518 pounds) in 1904. These two causes combined reduced the total quantity of beets converted into sugar from 6,505,048,530 kilos (14,341,-141,290 pounds) in 1903-4 to 4,669,454,772 kilos (10,294,394,001 pounds) in 1904-5. The average price of beets, in spite of the crop shortage, also fell from 22.39 francs ($4.32) per 100 kilos (220 pounds) in 1903 to 22.33 francs ($4.30) in 1904, so that each hectare planted in 1904-5 produced 509.40 francs ($98.31) to the grower instead of 614.87 francs ($118.67) in 1903-4.

The number of sugar mills in operation was 270 in 1904-5, against 292 in 1903-4. The product of the crop of beets grown in 1904 and manufactured in 1904-5 was 562,736,217 kilos (1,240,620,080 pounds) of sugar, including the sugar contained in the molasses shipped to distilleries and elsewhere. The product in 1903-4 was 727,267,622 kilos (1,603,350,405 pounds). The numbers of persons employed was: Men employed during defecation, 36,072; women, 2,319; children, 1,592; men employed after defecation, 5,975; women, 571; children, 199. The average of daily wages paid was: Men, 77 cents; women, 41 cents; children, 32 cents.

A new law in Australia provides for the payment after January 1, 1907, to every grower of white-grown cane or beet a bounty of 6 shillings ($1.50) per ton on cane giving 10 per cent. of sugar, to be increased or decreased proportionately according to any variation from that standard, and a bounty of 60 shillings ($15) per ton on the sugar-giving contents of the beet. It must be shown that the planter paid the standard rate of wages to his employees. There is to be an excise duty of $1 per hundred on manufactured sugar, but that is to be reduced on sugar produced from cane.

MAURITIUS.

Vice-Consul Blyth, of Port Louis, furnishes the trade statistics of the British Island of Mauritius for the fiscal year 1904-1905, as follows:

The total foreign commerce of Mauritius for the year 1904-1905 amounted to $25,000,000. The imports were $10,810,000, the principal items being:

Coal	$ 920,000
Cotton manufactures	475,000
Guano and fertilizers	173,000
Hardware and cutlery	321,000

Haberdashery	240,000
Oils	454,000
Rice	2,532,000
Wheat and wheat flour	429,000

Sugar is the great market crop of Mauritius, the exports for the year ending June 30, 1905, aggregating $13,000,000. The United States, which had not been buying sugar from the island, took 5,586 tons during the year in question. The exports of molasses increased 63 per cent. to 20,000 tons, nearly all of it going to India.

An organized attempt is being made to grow cotton in Mauritius, for which the soil is said to be well adapted. Seeds have been distributed and planted by small planters, while sugar estate managers have put out one to ten acres.

The production of tea is on the increase, but the local consumption increased so much faster that only 55 pounds were exported, against 795 pounds the year previous. The vanilla industry shows a decline on account of lower prices. The 50 per cent. decline in value is due to the large production in Mexico and the unexpected supplies furnished by the Comores Islands. If prices continue to fall, it seems probable that the exports from Mauritius will cease. These amounted for the fiscal year in question to 7,280 pounds, against 10,000 pounds in 1900, 41,000 pounds in 1895, and 51,000 pounds in 1889. Aloe fiber was exported to the value of $200,000.

THE SUGAR CAMPAIGN IN MEXICO.

In the Seventh Annual Yearly Sugar Report issued by Mr. Duncan Bankhardt, editor of *El Hacendado Mexicano,* Mexico, D. F., we find the following: "The sugar industry, which last year was so very promising owing to the advantageous prices obtained for the raw material in the London market and the corresponding good prices for the white sugar in the local markets, has been badly hit by the continual drop in foreign prices since last July, to such an extent that, with the exception of Demerara quality, it is impossible so far to export raw sugars and, therefore, the local market has also suffered by very low prices, which, nevertheless, are expected to rise to a point which is advantageous to all concerned, without any speculation on the part of trusts or private concerns.

"The granulated and cube sugar is gradually getting its footing in the country, and in a very few years, when the native sees that loaf sugar and panocho are only used by them, they will understand they ought to do like everybody else, and will then ask for and buy, at current prices, granulated, if not cube.

"A new cube factory started this year, that of the Rascon Sugar Factory, belonging to the Rascon Manufacturing & Development Company of New Orleans, and besides the granulated which they began to make, they are now turning out a very fair quality of cube. The total output is expected to attain about two million pounds this year, and a considerable increase is expected next season.

"All other factories are grinding, with the exception of one or two which have already finished. Several are turning their juices into alcohol instead of sugar, expecting to get better financial results.

"Modern machinery is continually replacing the old machinery, and scientific principles of sugar making are becoming more general."

Sugar Plantations, Cane Growers and Sugar Mills.

ISLAND AND NAME.		MANAGER.	POST OFFICE.
OAHU.			
Apokaa Sugar Co.	*	G. F. Renton	Ewa
Ewa Plantation Co.	*	G. F. Renton	Ewa
Waianae Co.	***	Fred Meyer	Waianae
Waialua Agricultural Co.	*	W. W. Goodale	Waialua
Kahuku Plantation Co.	x*	Andrew Adams	Kahuku
Waimanalo Sugar Co.	**	G. Chalmers	Waimanalo
Oahu Sugar Co.	x	E. K. Bull	Waipahu
Honolulu Plantation Co.	**	J. A. Low	Aiea
Laie Plantation	x*	S. E. Wooley	Laie
MAUI.			
Olowalu Co.	**	Geo. Gibb	Lahaina
Pioneer Mill Co.	x	L. Barkhausen	Lahaina
Wailuku Sugar Co.	**x	C. B. Wells	Wailuku
Hawaiian Commercial & Sug. Co.	x*	H. P. Baldwin	Puunene
Maui Agricultural Co		H. A. Baldwin	Paia
Kipahulu Sugar Co.	x	A. Gross	Kipahulu
Kihei Plantation Co.	x*	James Scott	Kihei
HAWAII.			
Paauhau Sugar Plantation Co.	**	Jas. Gibb	Hamakua
Hamakua Mill Co.	*x	A. Lidgate	Paauilo
Kukaiau Plantation	x	J. M. Horner	Kukaiau
Kukaiau Mill Co.	*x	E. Madden	Paauilo
Ookala Sugar Co.	**x	W. G. Walker	Ookala
Laupahoehoe Sugar Co.	*x	C. McLennan	Papaaloa
Hakalau Plantation	**	J. M. Ross	Hakalau
Honomu Sugar Co.	**x	Wm. Pullar	Honomu
Pepeekeo Sugar Co.	**x	Jas. Webster	Pepeekeo
Onomea Sugar Co.	**x	J. T. Moir	Hilo
Hilo Sugar Co.	**	J. A. Scott	Hilo
Hawaii Mill Co.	x	W. H. Campbell	Hilo
Waiakea Mill Co.	*x	C. C. Kennedy	Hilo
Hawaiian Agricultural Co.	**x	Wm. G. Ogg	Pahala
Hutchinson Sugar Plantation Co.	**	Carl Wolters	Naalehu
Union Mill Co.	*x	H. H. Renton	Kohala
Kohala Sugar Co.	*	E. E. Olding	Kohala
Pacific Sugar Mill	x**	D. Forbes	Kukuihaele
Honokaa Sugar Co.	x**	K. S. Gjerdrum	Honokaa
Olaa Sugar Co.	xx	J. Watt	Olaa
Puna Sugar Co.			Kapoho
Halawa Plantation	x*x	T. S. Kay	Kohala
Hawi Mill & Plantation	‡‡	John Hind	Kohala
Puako Plantation	‡‡	W. L. Vredenburg	S. Kohala
Niulii Sugar Mill and Plantation	*x	Robt Hall	Kohala
Puakea Plantation	*x	H. R. Bryant	Kohala
KAUAI.			
Kilauea Sugar Plantation Co.	**	A. Moore	Kilauea
Gay & Robinson	x*x	Gay & Robinson	Makaweli
Makee Sugar Co.		G. H. Fairchild	Kealia
Grove Farm Plantation	x	Ed. Broadbent	Lihue
Lihue Plantation Co.	x	F. Weber	Lihue
Koloa Sugar Co.	x	F. McLane	Koloa
McBryde Sugar Co.	*x	W. Stodart	Eleele
Hawaiian Sugar Co.	x*	B. D. Baldwin	Makaweli
Waimea Sugar Mill Co.	*	J. Fassoth	Waimea
Kekaha Sugar Co.	x	H. P. Faye	Kekaha

KEY.	HONOLULU AGENTS.	
*	Castle & Cooke	(5)
**	W. G. Irwin & Co.	(8)
***	J. M. Dowsett	(1)
x	H. Hackfeld & Co.	(9)
*x	T. H. Davies & Co.	(8)
**x	C. Brewer & Co.	(6)
x*	Alexander & Baldwin	(6)
x**	F. A. Schaefer & Co.	(2)
x*x	H. Waterhouse Trust Co.	(2)
‡‡	Hind, Rolph & Co	(2)
xx	Bishop & Co.	(1)